

US LHC Accelerator Project
Progress Report, 4th Quarter FY 2001
6 November 2001
J. Strait, Project Manager

I. Summary

Good technical progress continues across the Project. The prototype quadrupole program was completed after having met all requirements. All five D1 dipoles have been completed and the first unit is undergoing cold testing. Detailed design of the feedboxes is 80% complete, and 80% of the orders for the IR absorber have been placed and the large shielding parts received.

The project has a favorable cost variance of \$1.2M (+2%), and a schedule variance of -\$4.0M (-5%), \$0.4M better and \$0.8M worse than last quarter respectively. The changes were due to favorable material prices and re-baselining of the absorber task, that increased the BAC, offset by problems that occurred in D1 production and slow progress on the DFBX design. The EAC includes adjustments for several baseline changes that are in process but are not yet included in the BAC. Based on an earned value of \$70.9M, the project is 68% complete. The EAC is now \$103.9M.

The prototype quadrupole was successfully tested on a second cooldown to 2 K, exceeding 230 T/m on the second quench. Warm measurements of the first production collared coil were successfully completed, but the second production collared coil had to be disassembled to repair an electrical short. KEK cold mass and CERN corrector production are on schedule, but the beam tubes supplied by CERN will not arrive before February 2002. The quadrupole production schedule has been revised accordingly.

All five D1 dipoles were completed, but one of the magnets is in repair after having fallen when a lifting sling broke. The first unit was cold tested and easily exceeded the field for “ultimate” energy when the warm bore was removed. The first D2 cold mass is complete and the next three are in fabrication. Vacuum vessels are scheduled to arrive at the end of November.

The DFBX detailed design is about 80% complete, focusing on producing the roughly 300 drawings required. Four of nine DFBX interface specifications have been approved by CERN and two more are under formal review. Detailed design of the IR absorbers is essentially complete, and substantial progress has been made in placing procurements. The only remaining major procurement is the TAN beam tube. The prototype luminosity ionization chamber was successfully tested in the CERN test beam.

A new senior engineer has been appointed to be Deputy LBNL-LHC Project Manager for Engineering Production. He is specifically responsible for WBS level three management of the production of the DFBX, and will provide oversight of the production of the IR absorbers.

Cable testing is still limited by the rate at which production samples are being received.

Accelerator physics effort has centered on preparation for magnet acceptance, electron cloud simulations, impedance calculations for the TAN beam chamber, beam-beam effects, and energy deposition in the insertions.

II. Technical Status

1.1.1 IR quadrupoles

Following changes to the test stand, which reduced the heat load by 8 W, the prototype was cooled to 1.9 K for a second test in superfluid helium. The magnet exceeded the required 220 T/m in two quenches, as shown in Fig. 1. A subsequent test of the facility with no magnet present indicates an additional heat load coming from the beam vacuum tube in the feedbox. This cannot be easily repaired, and will be dealt with by adding cooling capacity. Assembly of the warm measurement stand was finished and commissioning begun. The harmonic amplitudes agree well with measurements with the older electric mole system.

The collared coil assembly for the first production cold mass, MQXB01, was completed. Collaring of the second magnet, MQXB02 was interrupted when a ground short, caused by a piece of weld flash from the collar pack assembly, was discovered. The coil and a damaged heater were replaced, and collaring of MQXB02 has resumed. Inspection of 100% of the collar packs has now been instituted. After MQXB02 has been collared, both magnets will be yoked and combined into the first Q2 cold mass assembly. Coil winding for MQXB03 will begin as soon as MQXB01 and MQXB02 are completed.

Nineteen unit lengths of outer cable were made at LBNL and samples sent to BNL for I_c testing. As soon as the I_c performance is verified, they will be sent to FNAL, completing the requirements for the MQXB production. Nine unit lengths worth of SSC wire will be maintained in reserve. The delivery of inner wire from OST has been delayed to mid-December. This is not of concern for the quadrupole schedule, but means the LBNL cabling schedule must be adjusted.

A trip to CERN led to some convergence on the beam vacuum interfaces. The beam tube flange design has been narrowed to two variants, both of which look acceptable to us, the cold-to-warm transition in front of Q1 remains in the cryostat, but the beam position monitor is outside (warm). CERN expects, but has not officially confirmed, that all absorbers in the Q1-Q2-Q3 magnets will be actively cooled.

The major concern at this point is the late delivery of beam tubes, now expected in February. This delays the test of the first complete Q2 to the point where, according to the

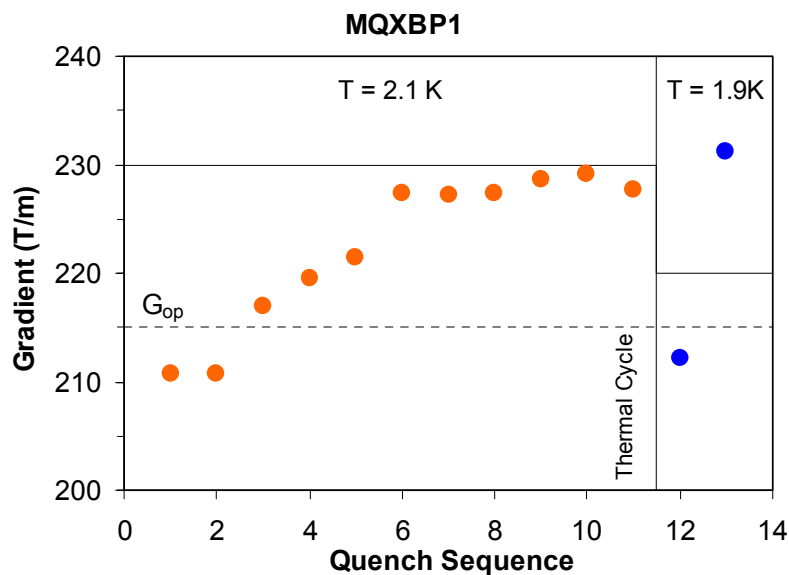


Figure 1. Quench training of the prototype inner triplet quadrupole

current production plan, four MQXB magnets will have been built, and the 5th and 6th will be well along. The building of a horizontal dewar, using the prototype cryostat, to allow quench testing of individual MQXB magnets prior to assembly into a full Q2, is under consideration.

1.1.2 Interaction Region Dipoles / 1.2.1. RF Region Dipoles

All five D1 magnets were assembled into cryostats (see Fig. 2) and the first is under cold test. In the first test, which included an evacuated warm bore, the quenches barely exceeded the nominal current, as shown in Fig. 3. On the second cooldown, in which a quench antenna was added, the performance was poorer. The warm bore was removed for a third cooldown, and better radiation shielding was installed

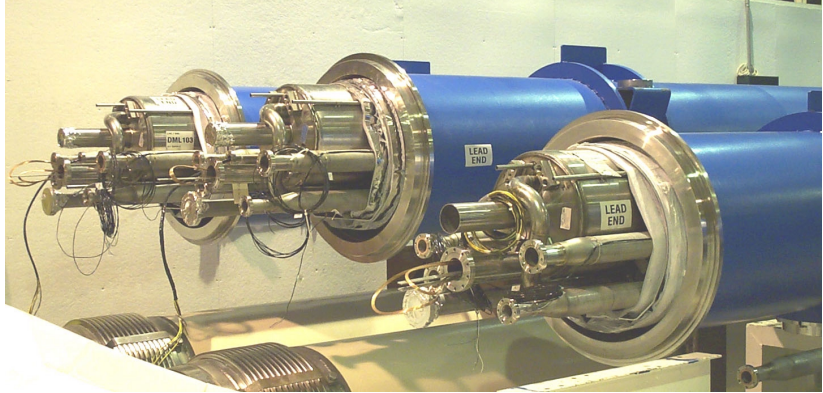


Figure 2. Three completed D1 magnets.

at the magnet ends. Under these conditions the magnet rapidly trained to 4.5 T, well above the LHC requirements and as good as the best RHIC magnets. The quench results show that, as expected, the cooling to the coil is poor due to the large beam tube, which has little clearance to the coil. This validates the decision to cool the D1 at 1.9K in the LHC.

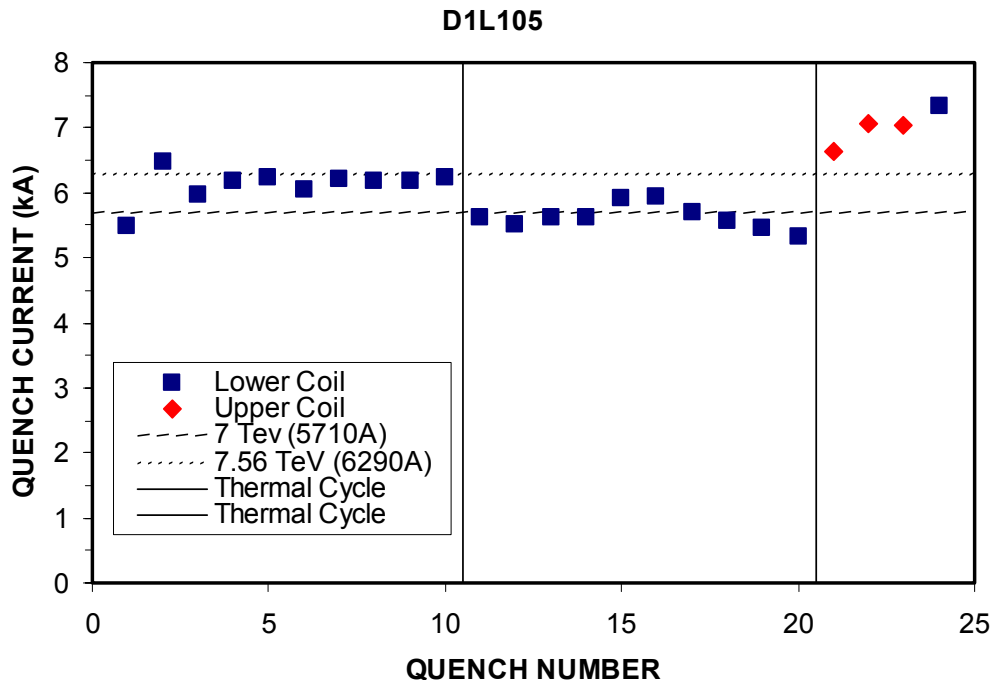


Figure 3. Quench training of the first production D1 dipole.

One D1 was damaged in a lifting accident when a sling broke. The cold mass appears to be not seriously damaged, and repair work has begun. As-built documentation on the D1 series is

being prepared using the engineering change notice system. Drawings for the D1 magnet post-testing/prepare to ship assembly and non-lead end interconnect design are in checking. The D1 magnet shipping fixture design is complete.

The first D2 cold mass is completed and is ready for cryostat assembly, and the second is nearly complete. Welding of the yoke/shell assembly is complete on the third D2 and electro-mechanical assembly is under way. One of the two apertures for the fourth D2 cold mass has been collared, and coils for all the remaining D2 are complete. The first four vacuum vessels are expected to be delivered at the end of November. Assembly continues on the cryostat insertion fixture, and the Horizontal Test Facility where the D2, D3 and D4 magnets will be tested.

An informal design review of the D3 dipoles was conducted at CERN to address some issues prior to the commencement of work leading to the Engineering Design Review early next year. Issues covered included the design of the instrumentation feed through system (IFS), attachment by CERN of a standard QQS cryostat to the D3 cryostat, and the reaction of axial forces due to the internal pressure in the cryogenic lines. CERN was in general agreement with the designs presented and only minor design modifications resulted.

1.1.3 Cryogenic lead and feed boxes

A new, detailed plan and schedule is being developed for the completion of the design and the preparation for production. The schedule is loaded with all engineering and design resources, to ensure that the plan is realistic and that all of the manpower required is brought to bear. Additional engineering and design staff have been added. The Production Readiness Review (PRR) is now expected to take place in March.

Documentation needed for production and procurement of the DFBX and required for the PRR, includes: design validation and safety notes; drawings and a bill of materials; assembly and fabrication plans; acceptance plans; a packing and shipping plan; a quality assurance plan; and list of documents to be delivered to CERN with the DFBX. The bill of materials has been generated. The structure of the top level assemblies is being finalized and the detailed drawings are under way. Each DFBX requires about 200 drawings, and approximately 300 different drawings are required for all eight DFBX. At the end of September, 225 drawings had been created, with 130 of those in the checking stage. Preliminary general assembly, piping assembly and test plans for DFBX boxes C, D, G and H were developed for two concepts of installing piping. Work has started on assembly plans for the helium tank and lambda plate assemblies. Minor design changes required by assembly considerations are being implemented. Of the nine interface specifications, four have been approved by CERN (the fourth just after the end of the quarter), one has been reviewed by CERN and returned for minor revisions, and two were about to be submitted as of the end of September.

Pirelli has received all the parts needed for manufacture of the first pair of HTS leads and is projecting completion of the first pair in early November. The test system at CERN is ready to accept these leads, and it appears that manpower will be available to test the Pirelli leads in November. Development of the lambda plate continues.

1.1.4 IR Absorbers

As with the feedboxes, a new, detailed plan and schedule, loaded with all required manpower resources, is being developed for the work required to prepare for assembly of the absorbers at LBNL. Progress has been slowed by the untimely deaths of both the lead technician and designer previously assigned to the absorber task. The Pre-Assembly Review is now

forecast to take place in January. Some of the simpler, initial assembly steps may begin earlier than that, following Project Office review of the preparations.

Good progress has been made placing orders for the TAN and TAS and 86 of a planned 111 procurements have been placed. The only major remaining procurement for the TAN is the beam tube. Preparations were made for a EDR of the TAN vacuum beam tube in early October. A new lead technician has been assigned, whose initial responsibilities will be to follow the progress of procurements, receive parts and prepare Building 60 for start of assembly.

Several meetings took place with CERN people regarding TAS interface issues. Several requests for design changes were made by the various TAS engineering groups at CERN. If these were simple to implement or were judged to reduce the cost of fabrication, they were accepted, otherwise they were declared too late to consider because the design had been completed and in some cases the materials had been ordered.

The luminosity instrumentation was tested in September at CERN in the SPS H4 test beam, to establish the 40 MHz capability of the instrumentation (see Fig. 4). The operation was much improved over last year: the waveform exhibited a smoothly decaying shape without the trailing damped oscillations seen previously, and, most importantly, it was demonstrated that under all operating conditions the peaking time is less than 25 nsec. Although the unbunched SPS beam does not produce proton showers at 40MHz, the performance was demonstrated by summing a sequence of proton showers delayed by 25nsec and showing that the energy from individual pulses can be accurately extracted. The magnitude of signals obtained and the variation with absorber thickness are in good agreement with the MARS code predictions.

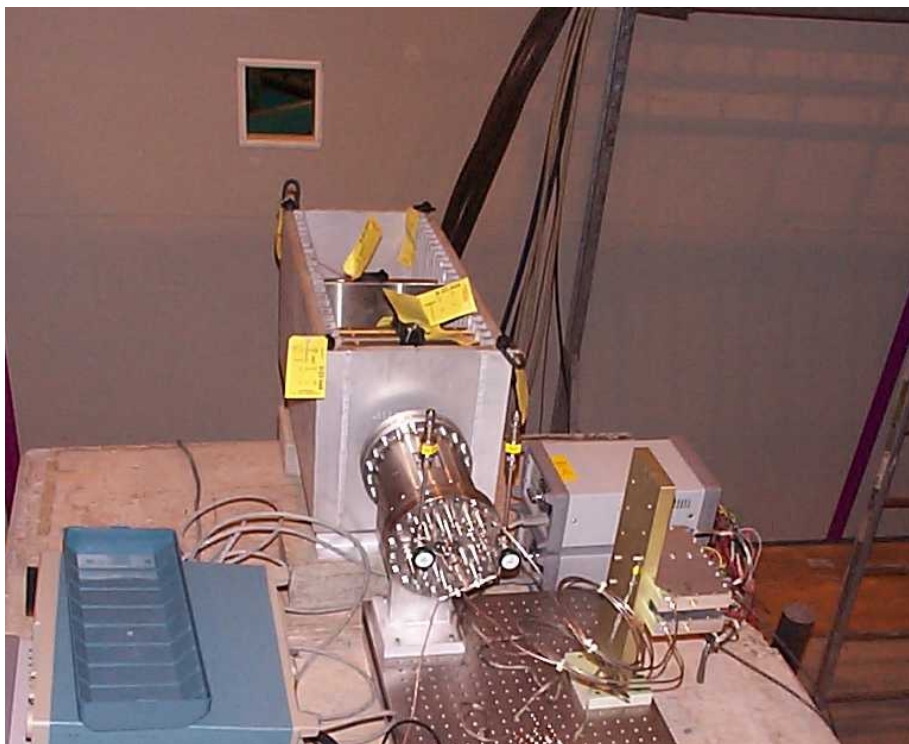


Figure 4. Prototype luminosity instrumentation the SPS test beam. The beam enters through the square hole in the wall at the back. The ionization chamber is in the cylindrical vessel, which is behind a box containing the steel absorber plates

1.1.5 IR System Design

The routing of the Q2 magnet electrical connections was confirmed using the full scale mockup of the inner triplet interconnections, including bus, expansion joints, splices, correction coils, instrumentation, warmup heaters and all associated wiring. A connector will be used for the instrumentation interconnects. A test on a prototype connector is planned to study the effects of discharging the heater power supply through the connector and its robustness over several thermal cycles. This material used in the connector is reported to have excellent radiation hardened properties, but this needs to be confirmed at levels expected in the inner triplet interconnects.

Stability of the beam vacuum requires that there be no continuous sections of the cold bore tube longer than about 1 m with the entire inner surface above 3 K. The Q1 beam tube is of concern because it is thicker than in the other quadrupoles and receives the greatest deposited energy from the IP. Calculations show that, for the beam tube thickness of 8.5 mm chosen to minimize peak power density in the coil, this criterion is satisfied for nominal but not for ultimate luminosity. Further calculations will be done to find a thickness which best balances safety margins with respect to peak power density in the coil versus cold bore temperature distribution.

1.3.1 Superconductor Testing

Cable test activity for the quarter consisted of 23 days at 4.3K, with 88 tests performed on LHC production cable and two tests on MQXB cable. The total number of cable tests per month appears in Table I. The test facility is still operating well below its capacity of 200 tests per quarter, due to slow cable production.

Table I. Number of superconducting cable tests, in units of EFTs ("Equivalent 4.2 K Tests").

EFT Equivalent 4.2K Test	No. Days @4.2K	Non- productive days	Fraction of cryo for LHC	No. of LHC EFTs	No. of MQXB EFTs	No. of RF Dipole EFTs	No. of Reference Cable Tests	Total
EFT Budget				3430	84	40	48	3602
Plan to Date				700	84	40	12	836
Total to Date	175	7		512	66	40	10	628
Oct-00	11	0	0.367	30	4	4	0	38
Nov-00	8	2	0.364	20	0	0	6	26
Dec-00	8	1	0.438	20	0	0	0	20
Jan-01	11	0	0.393	30	8	0	0	38
Feb-01	6	0	0.333	12	12	0	0	24
Mar-01	7	0	0.368	27	0	0	0	27
Apr-01	6	0	0.400	15	8	0	0	23
May-01	9	0	0.474	49	4	0	0	53
Jun-01	9	0	0.476	29	4	0	4	37
Jul-01	8	0	0.500	28	2	0	0	30
Aug-01	10	0	0.385	40	0	0	0	40
Sep-01	5	0	0.192	20	0	0	0	20
Total FY-01	98	3	0.391	320	38	4	10	372
Total FY-00	31	3		65	10	8		83
Total FY-99	46	1		127	18	28		173

1.3.2 Superconducting Cable Production Support

The only areas of activity are monitoring the contract with Humboldt Engineering for an additional two cable measuring machines, and occasional technical consultation to CERN on cabling issues. At a meeting at CERN in September, it was reported that the LHC dipole cabling work is ramping up toward the full production rate, and the cable quality appears to be good.

1.4 Accelerator Physics

Work has started at BNL to set up of the analysis and acceptance mechanism for the first D1 production dipole to be cold tested October. The RHIC acceptance process will be used as a reference, while making allowances for several differences regarding the US-LHC dipoles such as: the limited production of 20 magnets and the testing of 1.9 K D1 magnets only at 4.5 K.

Work has started on a revision of the LHC IR simulation in the light of results recently obtained by F. Schmidt at CERN, in which only the b_6 harmonic in the triplet seems to affect the dynamic aperture. Schmidt will be at BNL in November and results will be compared.

During a visit by Mathias Vogt (UNM) to Fermilab, work on parallelizing the beam-beam codes was begun. Work on the 4D phase space version of the serial code continued. Initial results show that the loss of Landau damping induced by the coherent beam-beam modes may be recovered by introducing an appropriate tune split between the beams.

Energy deposition studies were completed on the IP1/5 design, including modifications to the DFBX, and the effect of an additional mask in the Q1 cryostat to shield the IP end slide material from radiation coming through the space between the TAS and the experimental shielding. Studies checking the radiation hardness of the DU slide material, green putty, and hypertronics connectors were started, and in some cases completed. Work continued on completing the model of the IR6 region with test MARS runs for an unsynchronized abort.

A conceptual mistake was found in a formula used to fit the experimental data for the secondary electron energy spectrum, used in the electron cloud simulation code. The data have been re-fit with the corrected formula. Preliminary results from simulations of the essential cases do not appear to be qualitatively different from the old ones. Two LBNL physicists participated in electron-cloud measurements at the SPS, in collaboration with CERN personnel.

Calculations of the TAN vacuum chamber impedance, showing no trapped modes, were presented to CERN. CERN now approves the design of the TAN vacuum chamber as being acceptable from the impedance viewpoint.

III. Financial Status

Cost and Schedule Performance

The current performance data at WBS level 2 are summarized in Table II, and the changes since the last quarter for the program as a whole are contained in Table III. The CPR (Format 1, by WBS, and Format 2, by laboratory) for the 4th quarter of FY 2001 (the current period columns of the report represent three months of data) and three trend charts (cumulative performance, cost and schedule variances, and bull's-eye) are included as attachments. The favorable changes to the cost performance were due to favorable quadrupole cryostat material prices and the re-baselining of much of the LBNL program, which erased a significant negative cost variance in the absorber EDIA. These favorable variances were partially offset by D1 production problems at BNL. The negative changes to schedule performance were due to delays

in the dipole production schedules, a continuing delay in completing the DFBX design, and a delay in the start of absorber production.

Table II. Current cost performance data.

WBS	Cumulative Costs to Date					Costs at Completion		
	BCWS	BCWP	ACWP	SV	CV	BAC	EAC	VAC
1.1 Interaction Region	43,604	40,189	39,830	-3,415	+359	56,153	57,595	-1,442
1.2 RF Region	11,711	11,362	9,932	-349	+1,430	17,148	16,099	+1,050
1.3 SC Wire/Cable	7,638	7,451	7,381	-187	+70	13,225	13,225	0
1.4 Accel Physics	2,906	2,906	2,886	0	+20	3,606	3,331	+275
1.5 Project Mgt	8,984	8,984	9,698	0	-714	13,695	13,672	+23
Contingency						6,173	6,078	-95
Total	74,842	70,892	69,727	-3,951	+1,165	110,000	110,000	0*

*Note: Total VAC is equal to sum of WBS VACs minus the Contingency VAC.

Table III. Cost performance changes since the previous report.

	Last Quarter	This Quarter
Total Project Cost (TPC)	110,000K	110,000K
Budget At Completion (BAC)	103,196K	103,828K
Cum Budget to Date (BCWS)	69,851K	74,842K
Earned Value (BCWP)	66,700K	70,892K
Actual cost & commitments (ACWP)	65,934K	69,727K
Budgeted Cost of Work Remaining (BCWR)	36,496K	32,936K
Schedule Variance (SV)	-3,151K (-5%)	-3,951K (-5%)
Cost Variance (CV)	+766K (+1%)	+1,165K (+2%)
Estimate At Completion (EAC)	103,463K	103,922K
Contingency (TPC – EAC)	6,537K	6,078K
Contingency as a % of BCWR	17.9%	18.5%

Brookhaven's +\$71K cumulative cost variance is the net of a +\$388K variance in overheads and a -\$317K variance in direct costs. The favorable overhead variance was expected as explained in the previous quarterly report. The unfavorable direct cost variance is due to production problems with the IR dipoles, most notably the D1s. BNL's -\$1,218K cumulative schedule variance is the result of production delays. Some were caused by rework of D1 cold masses and some are being caused by late deliveries of cryostats.

Fermilab's +\$566K cumulative cost variance is due to favorable bids being received for the cryostat parts. The +\$468K cumulative schedule variance is due to ordering cryostat parts earlier than planned.

Berkeley's +\$527K cumulative cost variance is still dominated by the favorable price achieved on the HTS leads for the DFBX, and recent favorable prices for absorber parts have increased the positive variance. The -\$3,201K cumulative schedule variance is a combination of continuing slow progress in completing the design the DFBX, and the later than planned ordering of absorber parts.

Estimate At Completion (EAC)

The EAC has increased by \$459K since last quarter. This is a net of incorporating an estimate of the potential DFBX cost increase, offset by decreases in work scope (AP reduction and dipole magnet quantity reduction) and recent cost savings in material purchases.

Baseline Change Requests

Ten Baseline Change Requests (BCR) were considered this quarter. BCRs 27 (LBNL absorber re-baseline), 29 (LBNL cable, accelerator physics, and project management re-baseline), 30 (FNAL-LHC production re-baseline), 31 (FNAL test stand commissioning) and 35 (DFBX Fabrication Study) were approved and are incorporated into the baseline budget reported above. (BCR30 and 31 were approved during this quarter, but before the previous quarterly report was submitted, and their changes were included in the baseline budget reported last time.) BCR 36 (Reduction in FY2002 accelerator physics effort) was approved at the end of the quarter, but has not been incorporated into the baseline yet. However, it is included in the EAC. BCR 28 (DFBX re-baseline) was rejected in its current form by the Interlab Steering Committee, and a new cost estimate and program plan is being developed. However, the cost presented in BCR 28 is included in the EAC. BCR 32 (RF dipole quantity reduction) is ready for submission except for final details, and it should be incorporated into the baseline for the next report. Its value is included the EAC.

Two BCRs, 33 and 34, were also approved to bring the milestones for the IR absorbers and the IR luminosity instrumentation into alignment with the baseline schedules and work scope approved by previous BCRs.

Funding

Funding of \$9.8M from the CERN Direct Pay account, for which no invoices have been received from CERN, were made available to the US LHC Accelerator Project in August and September. BNL received \$0.2M in operating funds to ensure that sufficient money would be available to finish the fiscal year. As it turned out, they were not required, and are being carried over. FNAL received \$0.5M in capital equipment funds to allow early order of parts. To some extent, this occurred, but the favorable prices achieved rendered the advance unnecessary. The remaining \$9.1M was placed in a special holding account at FNAL to be distributed later as part of the FY02 funding allocation. Not counting the \$9.8M, the Project carried over \$2.8M of obligated funds and \$3.0M of unobligated funds.

The cumulative funding, obligation and expenditure profiles are shown in an attachment. The Project funding profile has been revised to be as shown in Table IV. This revision provides funds earlier than planned to alleviate a potential shortfall that had been identified for FY02. The CERN Direct Pay profile changed in direct proportion such that the total accelerator funds provided by DOE for each FY remained constant.

Table IV. New funding profile

FY02	FY03	FY04	FY05
\$10.10M	\$8.70M	\$6.13M	\$2.92M

IV. Milestone Status

Table V lists all level 1 and 2 milestones from the beginning of the Project through FY2002, and Table VI shows the level 3 milestones affected during the quarter. Changes are highlighted in bold print. Actual dates are shown for completed milestones and forecast dates are given for milestones that have slipped out of the quarter or, due to pending changes in the program schedule, are expected to be achieved at times substantially different from the baseline dates. Level 2 milestones for deliveries to CERN are based on out-dated schedules, both ours and CERN's, and will be revised by a BCR currently in process. Level 1 and 2 milestones are displayed graphically in an attachment. The forecast dates have been entered for milestones with baseline dates through the end of FY2002.

Table VI. Level 1 and 2 U.S. LHC Accelerator Baseline Milestones through FY2002.

WBS		Baseline	Forecast(F)
<u>Identifiers</u>	<u>Milestone Description</u>	<u>Date</u>	<u>or Actual(A)</u>
Project	Decision as to whether or not the US Project includes RF region quadrupoles	1 Jul 01	20 Jun 01 (A)
Int Region	Begin 1st inner triplet quadrupole model magnet	1 Jul 97	1 Jul 97 (A)
Int Region	Complete inner triplet quadrupole model magnet program phase 1	1 Dec 99	28 Sep 99 (A)
Int Region	Complete inner triplet quadrupole model magnet program phase 2	1 Mar 00	17 Mar 00 (A)
Int Region	Place purchase order for HTS power leads	1 Feb 00	30 Aug 00 (A)
Int Region	Begin absorber fabrication	1 Nov 00	30 Oct 00 (A)
Int Region	Complete inner triplet quadrupole prototype program	1 Oct 01	31 Aug 01 (A)
Int Region	Begin IR beam separation dipole production assembly	1 Oct 00	25 Jul 00 (A)
Int Region	Begin inner triplet feedbox fabrication	1 Mar 01	15 Apr 02 (F)
Int Region	Begin inner triplet quadrupole production assembly	1 Nov 01	1 May 01 (A)
Int Region	Complete 1 st inner triplet quadrupole magnet	1 Sep 02	1 Sep 02 (F)
Int Region	Delivery of D2 for IR8 left	1 Apr 02	15 May 02 (F)
Int Region	Complete inner triplet feedbox fabrication	1 May 02	1 Nov 03 (F)
RF Region	Begin assembly of 1st dipole model magnet	1 Sep 99	10 Jun 99 (A)
RF Region	Complete dipole model magnet program	1 Aug 00	8 Nov 00 (A)
RF Region	Begin RF region dipole production assembly	1 Jan 02	1 Jan 02 (F)
RF Region	Delivery of D3, D4 for IR4 right	1 Jan 02	15 Jun 03 (F)
SC Cable	All cable prod. support equipment delivered to CERN	1 Sep 99	28 May 99 (A)
SC Cable	Complete SC testing facility upgrades	1 Jun 99	30 Sep 99 (A)

Table V. Changes to Level 3 U.S. LHC Accelerator Baseline Milestones during current quarter.

WBS		Baseline	Forecast(F)
<u>Identifiers</u>	<u>Milestone Description</u>	<u>Date</u>	<u>or Actual(A)</u>
Int Region	MQXB to LQX Cryostat Interface Specification approved	15 Oct 00	11 Jul 01 (A)
Int Region	MQXA to LQX Cryostat Interface Specification approved	1 Jan 01	1 Jan 02 (F)
Int Region	LQX Functional Specification approved	1 Dec 00	1 Jan 02 (F)
Int Region	TAS2/3 Functional Specification approved	1 Dec 00	1 Jan 02 (F)
Int Region	Inner Triplet Corrector Interface Specifications approved	15 Oct 00	1 Jan 02 (F)
Int Region	LQX Tunnel Installation and Alignment Specification Approved	1 Jun 01	1 Jan 02 (F)
Int Region	LQX (Q3) to DFBX Interface Specification approved	15 Oct 00	13 Jul 01 (A)
Int Region	LQX to Cold Bore Tube Interface Specification approved	1 Jan 01	1 Feb 02 (F)
Int Region	LQX to BPM Interface Specification Approved	1 Apr 01	1 Jan 02 (F)
Int Region	LQX to LQX Interface Specification Approved	1 Jun 01	1 Jan 02 (F)
Int Region	LQX to Warm Beam Vacuum Interface Specification Approved	1 Jun 01	1 Jan 02 (F)
Int Region	Complete Prototype Magnet Program	15 Jul 01	31 Aug 01 (A)
Int Region	MQX Production Readiness Review	15 Jul 01	1 Feb 02 (F)
Int Region	Complete Production of Cable and Wedges for Production MQXB	1 Jul 01	31 Jan 02 (F)
Int Region	D1 Production Complete	19 Jun 01	1 Jan 02 (F)
Int Region	DFBX Interface Specifications approved	1 Jul 99	1 Jan 02 (F)
Int Region	DFBX Production Readiness Review	1 Nov 00	15 Apr 02 (F)
Int Region	Begin Fabrication of First DFBX	1 Dec 00	15 Apr 02 (F)
Int Region	IR1 and IR5 DFBXs Ready to Ship	1 Sep 01	4 Apr 03 (F)
RF Region	D4 Interface Specification Approved	1 May 01	22 Dec 01 (F)
RF Region	D3 Interface Specification Approved	15 Sep 01	25 Feb 02 (F)
RF Region	D3 Engineering Design Review	1 Sep 01	1 Apr 02 (F)
RF Region	Delivery by CERN to BNL of all CERN-provided D4 parts	1 Jul 01	12 Feb 02 (F)

CLASSIFICATION (When filled in)

COST PERFORMANCE REPORT												Page 1 of 2				
FORMAT 1 - WORK BREAKDOWN STRUCTURE												DOLLARS IN Thousands				
1. CONTRACTOR				2. CONTRACT				3. PROGRAM				4. REPORT PERIOD				
a. NAME US LHC Accelerator Project Office				a. NAME US LHC by Qtr				a. NAME US LHC Accelerator Project				a. FROM (YYMMDD) 010701				
b. LOCATION (Address and ZIP Code) MS 343 PO Box 500 Batavia, IL 60510				b. NUMBER 1				b. PHASE (X one) x RDT&E x PRODUCTION				b. TO (YYMMDD) 010930				
c. TYPE FPI				d. SHARE RATIO 100/0 100/0												
5. CONTRACT DATA																
a. QUANTITY 0/0/0	b. NEGOTIATED COST \$103,827.6	c. EST. COST AUTH UNPRICED WORK \$0.0	d. TARGET PROFIT/ FEE \$0.0 / 0.0%	e. TARGET PRICE \$103,827.6	f. ESTIMATED PRICE \$103,921.9	g. CONTRACT CEILING \$110,000.0	h. ESTIMATED CONTRACT CEILING \$110,000.0									
6. ESTIMATED COST AT COMPLETION								7. AUTHORIZED CONTRACTOR REPRESENTATIVE								
MANAGEMENT ESTIMATE AT COMPLETION (1)		CONTRACT BUDGET BASE (2)		VARIANCE (3)		a. NAME (Last, First, Middle Initial) Jim Strait				b. TITLE Project Manager						
a. BEST CASE		\$103,921.9				c. SIGNATURE				d. DATE SIGNED (YYMMDD) 011102						
b. WORST CASE		\$103,921.9														
c. MOST LIKELY		\$103,921.9		\$103,827.6		-\$94.3										
8. PERFORMANCE DATA																
ITEM (1)	CURRENT PERIOD						CUMULATIVE TO DATE					REPROGRAMMING ADJUSTMENTS		AT COMPLETION		
	BUDGETED COST		ACTUAL COST WORK PERFORMED (4)	VARIANCE		BUDGETED COST		ACTUAL COST WORK PERFORMED (9)	VARIANCE		COST VARIANCE (12)	BUDGET (13)	BUDGETED (14)	ESTIMATED (15)	VARIANCE (16)	
	WORK SCHEDULED (2)	WORK PERFORMED (3)		SCHEDULE (5)	COST (6)	WORK SCHEDULED (7)	WORK PERFORMED (8)		SCHEDULE (10)	COST (11)						
a. WORK BREAKDOWN STRUCTURE ELEMENT																
1.1 - Interaction Reg	2	3,101.3	2,513.4	2,333.9	-587.8	179.6	43,604.4	40,189.2	39,830.1	-3,415.2	359.1			56,153.4	57,595.5	-1,442.1
1.1.1 - Quadrupoles	3	839.1	1,162.7	690.9	323.5	471.8	26,268.4	26,735.1	26,259.2	466.7	475.9			34,638.6	34,376.0	262.6
1.1.2 - Dipoles	3	924.3	451.4	785.6	-472.9	-334.2	7,166.1	6,483.6	7,140.0	-682.5	-656.3			8,863.6	8,863.5	0.1
1.1.3 - Cryo Feedboxes	3	355.9	60.3	300.8	-295.6	-240.5	5,566.3	3,000.0	2,718.6	-2,566.3	281.4			6,728.3	8,510.6	-1,782.3
1.1.4 - Absorbers	3	930.6	787.7	486.1	-142.9	301.6	3,851.4	3,218.2	2,953.4	-633.2	264.8			4,997.7	4,877.6	120.1
1.1.5 - System Design	3	51.4	51.4	70.5	0.0	-19.1	752.2	752.2	758.9	0.0	-6.7			925.1	967.8	-42.7
1.2 - RF Region	2	794.4	656.0	441.0	-138.4	215.0	11,710.7	11,362.1	9,932.1	-348.6	1,430.1			17,148.2	16,098.6	1,049.6
1.2.1 - Dipoles	3	794.4	656.0	441.0	-138.4	215.0	11,710.7	11,362.1	9,932.1	-348.6	1,430.1			17,148.2	16,098.6	1,049.6
1.3 - SC Wire & Cable	2	260.4	186.5	244.3	-73.8	-57.7	7,637.6	7,450.8	7,380.6	-186.8	70.2			13,225.1	13,225.0	0.1
1.3.1 - SC Testing	3	316.5	242.5	243.7	-74.1	-1.2	6,615.9	6,429.1	6,320.0	-186.8	109.1			12,192.1	12,192.1	-0.00
1.3.2 - Cable Prod S'pt	3	-56.2	-55.9	0.5	0.2	-56.5	1,021.8	1,021.8	1,060.7	0.0	-38.9			1,033.0	1,032.9	0.1
1.4 - Accel Physics	2	242.0	242.0	192.0	0.0	50.0	2,905.8	2,905.8	2,886.1	0.0	19.7			3,606.2	3,331.0	275.2
1.5 - Project Mgt	2	593.4	593.4	581.7	0.0	11.7	8,983.9	8,983.9	9,698.3	0.0	-714.4			13,694.8	13,671.6	23.2
OV - OVERHEAD	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0

CLASSIFICATION (When filled in)

Unclassified

CLASSIFICATION (When filled in)

COST PERFORMANCE REPORT

FORMAT 1 - WORK BREAKDOWN STRUCTURE

DOLLARS IN Thousands

Page 2 of 2

8. PERFORMANCE DATA

ITEM	CURRENT PERIOD					CUMULATIVE TO DATE					REPROGRAMMING		AT COMPLETION			
	BUDGETED COST		ACTUAL COST WORK PERFORMED	VARIANCE		BUDGETED COST		ACTUAL COST WORK PERFORMED	VARIANCE		ADJUSTMENTS		BUDGETED	ESTIMATED	VARIANCE	
	WORK SCHEDULED	WORK PERFORMED		SCHEDULE	COST	WORK SCHEDULED	WORK PERFORMED		SCHEDULE	COST	COST VARIANCE	BUDGET				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	
a. WORK BREAKDOWN STRUCTURE ELEMENT																
b. COST OF MONEY	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0	
c. GENERAL & ADMINISTRATIVE	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0	
d. UNDISTRIBUTED BUDGET	2												0.0	0.0	0.0	
e. SUBTOTAL (Performance Measurement Baseline)		4,991.5	4,191.4	3,792.8	-800.1	398.6	74,842.5	70,891.9	69,727.2	-3,950.6	1,164.7	0.0	0.0	103,827.6	103,921.7	-94.1
f. MANAGEMENT RESERVE	2											0.0	0.0			
g. TOTAL		4,991.5	4,191.4	3,792.8	-800.1	398.6	74,842.5	70,891.9	69,727.2	-3,950.6	1,164.7	0.0	0.0	103,827.6		
9. RECONCILIATION TO CONTRACT BUDGET BASE																
a. VARIANCE ADJUSTMENT										0.0	0.0					
b. TOTAL CONTRACT VARIANCE										-3,950.6	1,164.7			103,827.6	103,921.7	-94.1

Unclassified

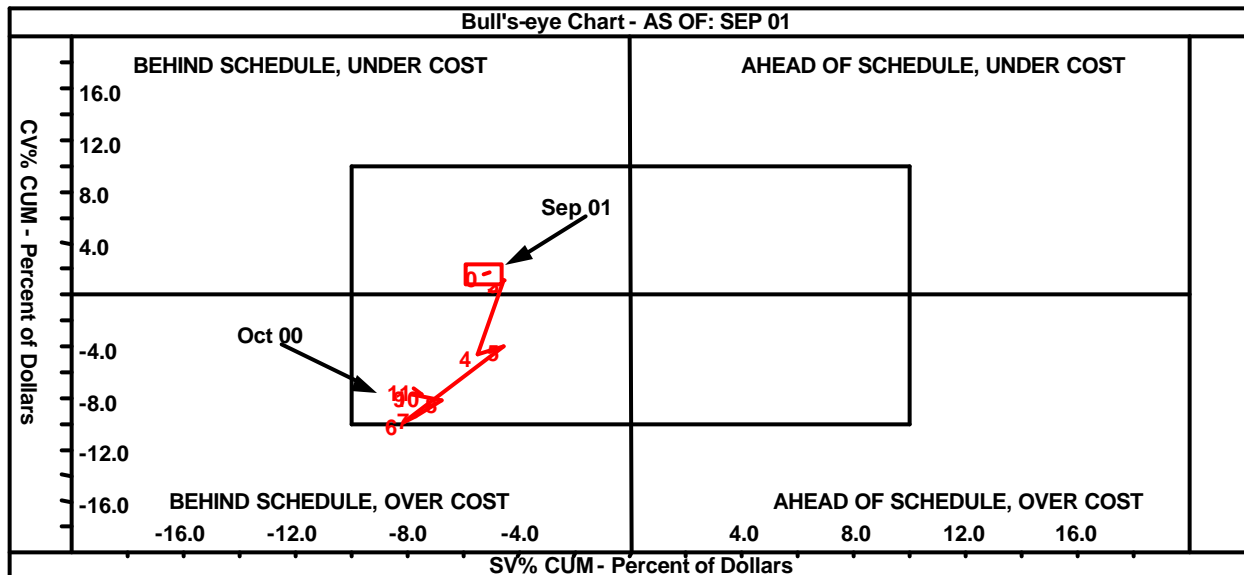
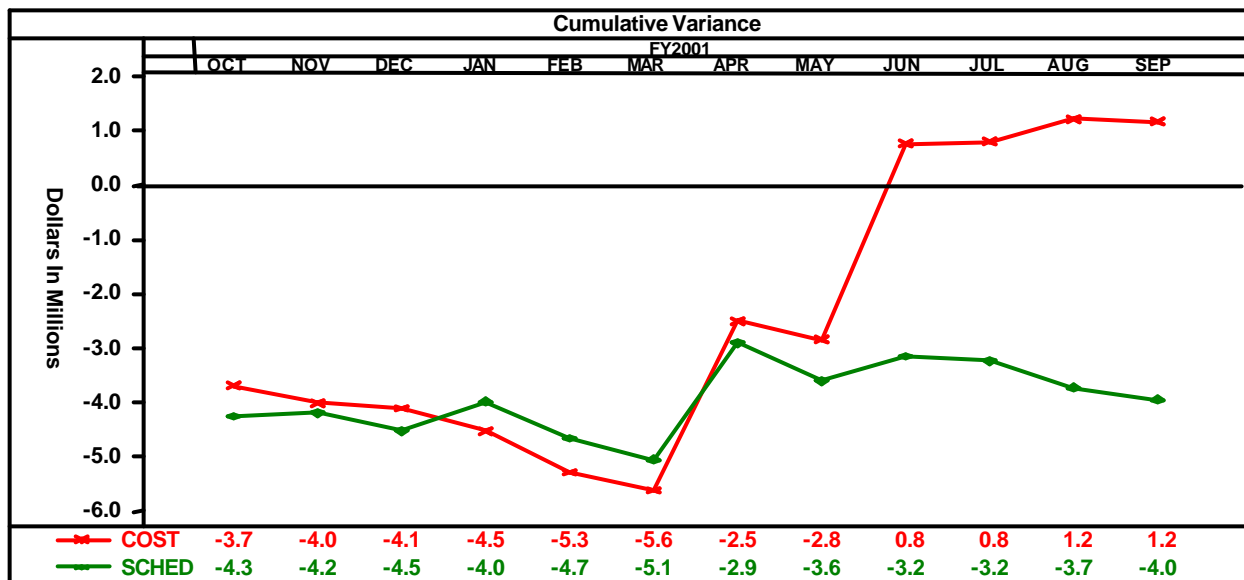
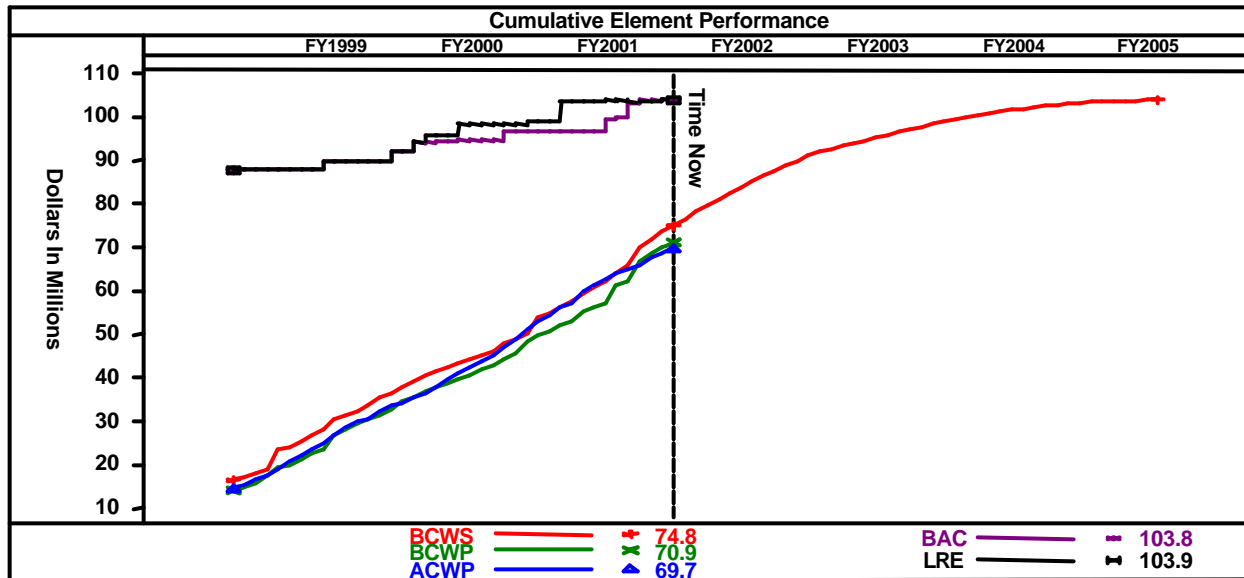
CLASSIFICATION (When filled in)

CLASSIFICATION (When filled in)

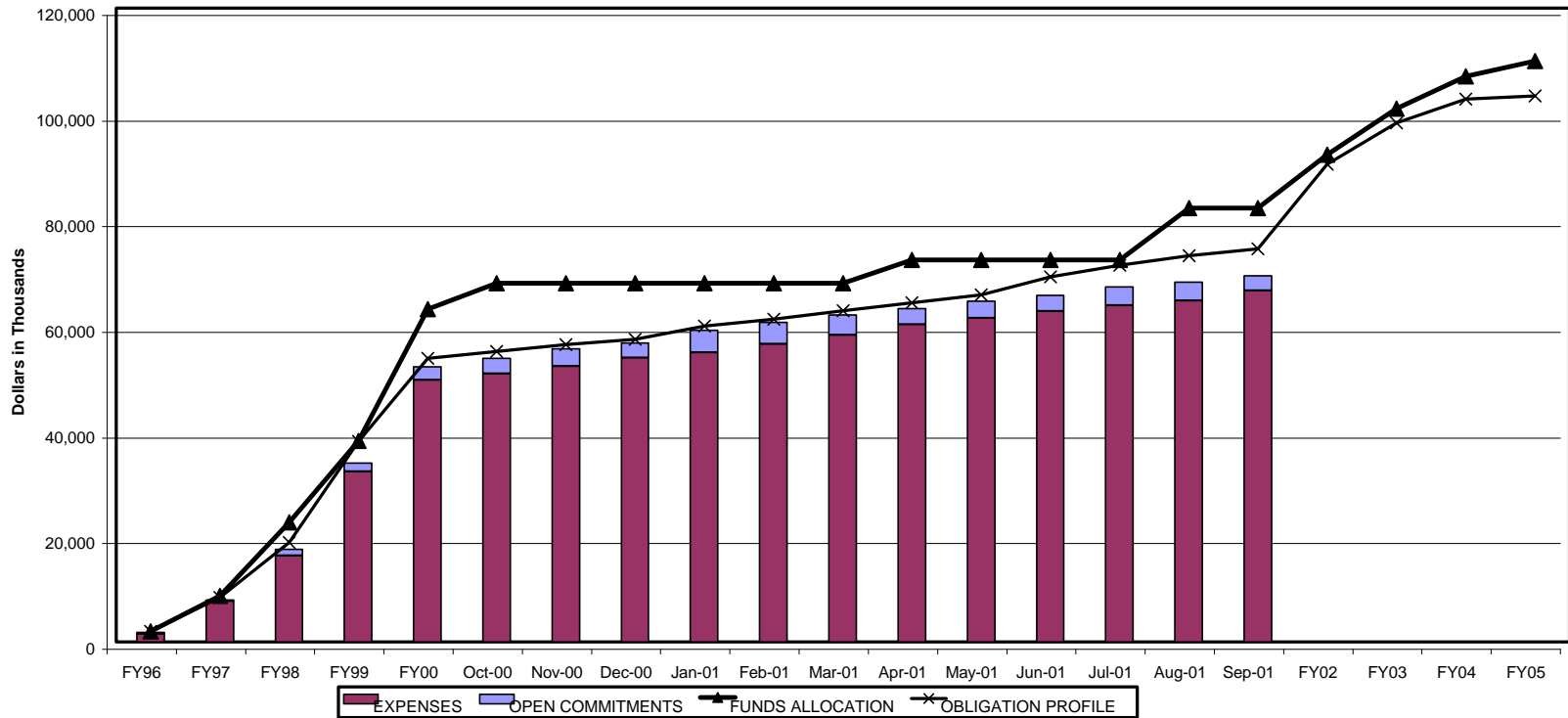
COST PERFORMANCE REPORT												Page 1 of 1				
FORMAT 2 - ORGANIZATIONAL CATEGORIES										DOLLARS IN Thousands						
1. CONTRACTOR				2. CONTRACT				3. PROGRAM				4. REPORT PERIOD				
a. NAME US LHC Accelerator Project Office				a. NAME US LHC by Qtr				a. NAME US LHC Accelerator Project				a. FROM (YYMMDD) 010701				
b. LOCATION (Address and ZIP Code) MS 343 PO Box 500 Batavia, IL 60510				b. NUMBER 1				b. PHASE (X one) <input checked="" type="checkbox"/> RDT&E <input checked="" type="checkbox"/> PRODUCTION				b. TO (YYMMDD) 010930				
				c. TYPE FPI		d. SHARE RATIO 100/0 100/0										
5. PERFORMANCE DATA																
ITEM (1)	CURRENT PERIOD					CUMULATIVE TO DATE					REPROGRAMMING		AT COMPLETION			
	BUDGETED COST		ACTUAL COST WORK PERFORMED (4)	VARIANCE		BUDGETED COST		ACTUAL COST WORK PERFORMED (9)	VARIANCE		ADJUSTMENTS		BUDGETED (14)	ESTIMATED (15)	VARIANCE (16)	
	WORK SCHEDULED (2)	WORK PERFORMED (3)		SCHEDULE (5)	COST (6)	WORK SCHEDULED (7)	WORK PERFORMED (8)		SCHEDULE (10)	COST (11)	COST VARIANCE (12)	BUDGET (13)				
a. ORGANIZATIONAL CATEGORY																
BNL -	2	2,286.0	1,600.7	1,769.0	-685.3	-168.3	30,646.7	29,428.8	29,357.7	-1,217.9	71.1			45,131.8	43,893.0	1,238.8
FNAL -	2	1,006.6	1,313.9	1,028.7	307.3	285.2	29,439.8	29,907.8	29,341.6	468.1	566.2			40,596.9	40,267.7	329.2
LBNL -	2	1,698.8	1,276.8	995.1	-422.1	281.7	14,756.0	11,555.2	11,027.8	-3,200.8	527.4			18,098.9	19,761.2	-1,662.3
OV - OVERHEAD	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0
b. COST OF MONEY	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0
c. GENERAL & ADMINISTRATIVE	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0
d. UNDISTRIBUTED BUDGET	2													0.0	0.0	0.0
e. SUBTOTAL (Performance Measurement Baseline)		4,991.5	4,191.4	3,792.8	-800.1	398.6	74,842.5	70,891.9	69,727.2	-3,950.6	1,164.7	0.0	0.0	103,827.6	103,921.9	-94.3
f. MANAGEMENT RESERVE	2												0.0	0.0		
g. TOTAL		4,991.5	4,191.4	3,792.8	-800.1	398.6	74,842.5	70,891.9	69,727.2	-3,950.6	1,164.7	0.0	0.0	103,827.6		

CLASSIFICATION (When filled in)

COST/SCHEDULE PERFORMANCE CHARTS



US LHC FINANCIAL TRACKING DATA REVISED FUNDING PROFILE



	FY96	FY97	FY98	FY99	FY00	Oct-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01	May-01	Jun-01	Jul-01	Aug-01	Sep-01	FY02	FY03	FY04	FY05
INCREMENTAL																					
FUNDS ALLOCATION	2,000	6,670	14,000	15,400	24,917	4,900	0	0	-11	0	0	4,473	0	0	0	9,804	0	10,096	8,700	6,130	2,921
OBLIGATION PROFILE	1,962	6,427	10,466	19,155	15,714	1,222	1,384	944	2,537	1,294	1,644	1,437	1,570	3,314	2,210	1,880	1,283	16,011	7,828	4,494	580
EXPENSES	1,515	6,186	8,594	15,946	17,307	1,248	1,356	1,606	994	1,610	1,703	2,057	1,225	1,291	1,105	884	1,908				
OPEN COMMITMENTS	296	-43	964	366	965	372	377	-436	1,336	-74	-267	-847	168	-248	540	-29	-612				
CUMULATIVE																					
FUNDS ALLOCATION	2,000	8,670	22,670	38,070	62,987	67,887	67,887	67,887	67,876	67,876	67,876	72,349	72,349	72,349	72,349	82,153	82,153	92,249	100,949	107,079	110,000
OBLIGATION PROFILE	1,962	8,390	18,856	38,011	53,725	54,947	56,331	57,275	59,812	61,105	62,750	64,187	65,758	69,071	71,282	73,162	74,445	90,456	98,284	102,778	103,358
EXPENSES	1,515	7,701	16,296	32,242	49,549	50,797	52,153	53,758	54,752	56,362	58,065	60,123	61,348	62,639	63,744	64,628	66,537				
OPEN COMMITMENTS	296	253	1,217	1,582	2,547	2,919	3,296	2,860	4,196	4,122	3,856	3,008	3,176	2,928	3,469	3,440	2,828				

Number	ID	Milestone	Original	Revised	Forecast	Actual	Variance	1996				1997				1998				1999				2000				2001				2002				2003				2004				2005			
								1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4				
1-1		Project Start (10/1/95)	10/1/95	10/1/95	10/1/95	10/1/95	0 days																																								
2-1.1-1	IR	Begin 1st Inner Triplet Quadrupole Model Magnet	7/1/97	7/1/97	7/1/97	7/1/97	0 days																																								
2-1.3-1	SC	Complete Superconductor Test Facility Upgrades	6/1/99	6/1/99	9/30/99	9/30/99	87 days																																								
2-1.3-2	SC	All Cable Production Support Equipment Delivered to CERN	9/1/99	9/1/99	5/28/99	5/28/99	-68 days																																								
2-1.2-1	RF	Begin Assembly of 1st Dipole Model Magnet	9/1/99	9/1/99	6/10/99	6/10/99	-59 days																																								
2-1.1-2	IR	Complete Inner Triplet Quadrupole Model Magnet Program Phase 1	12/1/99	12/1/99	9/28/99	9/28/99	-46 days																																								
2-1.1-4	IR	Place Purchase Order for HTS Power Leads	2/1/00	2/1/00	8/30/00	8/30/00	151 days																																								
2-1.1-3	IR	Complete Inner Triplet Quadrupole Model Magnet Program Phase 2	3/1/00	3/1/00	3/17/00	3/17/00	12 days																																								
2-1.2-2	RF	Complete Dipole Model Magnet Program	8/1/00	8/1/00	11/8/00	11/8/00	71 days																																								
2-1.2-3	RF	Begin RF Region Dipole Production Assembly	9/1/00	1/1/02	1/1/02	NA	0 days																																								
2-1.1-5	IR	Begin Absorber Fabrication	11/1/00	11/1/00	10/30/00	10/30/00	-2 days																																								
2-1.1-6	IR	Complete Inner Triplet Quadrupole Prototype Magnet Program	12/1/00	10/1/01	8/31/01	8/31/01	-21 days																																								
2-1.1-7	IR	Begin Interaction Region Beam Separation Dipole Prod. Assembly	3/1/01	10/1/00	7/25/00	7/25/00	-49 days																																								
2-1.1-8	IR	Begin Inner Triplet Feedbox Fabrication	3/1/01	3/1/01	4/15/02	NA	292 days																																								
2-1.1-9	IR	Begin Inner Triplet Quadrupole Production Assembly	4/15/01	11/1/01	5/1/01	5/1/01	-132 days																																								
1-2		Decision on RF Region Quadrupoles	7/1/01	7/1/01	6/20/01	6/20/01	-8 days																																								
2-1.1-10	IR	Complete 1st Inner Triplet Quadrupole Magnet	11/1/01	9/1/02	9/1/02	NA	0 days																																								
2-1.2-4	RF	Delivery of D3, D4 for IR4 right	1/1/02	1/1/02	6/15/02	NA	119 days																																								
2-1.1-11	IR	Delivery of D2 for IR8 Left	4/1/02	4/1/02	5/15/02	NA	32 days																																								
2-1.1-12	IR	Complete Inner Triplet Feedbox Fabrication	5/1/02	5/1/02	11/1/03	NA	393 days																																								
2-1.1-13	IR	Delivery of All Inner Triplet System Components for IR8 Left (MQX, DFBX, D1)	10/1/02	10/1/02	10/1/02	NA	0 days																																								
2-1.2-5	RF	Complete RF Region Dipole Production Assembly	10/1/02	10/1/02	10/1/02	NA	0 days																																								
2-1.1-14	IR	Delivery of D2 for IR5 Left	11/1/02	11/1/02	11/1/02	NA	0 days																																								
2-1.2-6	RF	Delivery of D3, D4 for IR4 left	11/1/02	11/1/02	11/1/02	NA	0 days																																								
2-1.1-15	IR	Complete Absorber Fabrication	12/1/02	2/1/03	2/1/03	NA	0 days																																								
2-1.1-16	IR	Delivery of All Inner Triplet System Components for IR8 Right (MQX, DFBX, D1)	1/1/03	1/1/03	1/1/03	NA	0 days																																								
2-1.1-17	IR	Delivery of D2 for IR8 Right	2/1/03	2/1/03	2/1/03	NA	0 days																																								
2-1.1-18	IR	Complete Interaction Region Dipole Production Assembly	3/1/03	3/1/03	3/1/03	NA	0 days																																								
2-1.1-30	IR	Complete Inner Triplet Quadrupole Production	9/1/04	3/1/05	3/1/05	NA	0 days																																								
2-1.3-3	SC	Series Wire and Cable Testing Complete	10/1/04	3/31/05	3/31/05	NA	0 days																																								
1-3		Project Completion (9/30/05)	9/30/05	9/30/05	9/30/05	NA	0 days																																								

Date: 11/6/01

Revised Baseline ○

Forecast

Actual 